MUSEUMS AS A MIRROR OF SOCIETY: A DARWINIAN LOOK AT THE DEVELOPMENT OF MUSEUMS AND COLLECTIONS OF SCIENCE

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Abstract

Following the Darwinian approach, which describes a form in nature as the functional adaptation to its environment at a given time, I will explore the development of museums and collections of science as an expression of their function in historical and social context. This approach allows us to establish a classification of scientific museums where features like owner, user, role and use of the object and its social, cultural and intellectual environment act as discriminating factors. This approach may stimulate discussion about how a museum of science could develop to remain attuned to the characteristics and demands of its specific environment, and hence prove to be viable.

Introduction

Sir Winston Churchill's statement, "We shape our environment, and then our environment shapes us," elegantly summarizes the way that society shapes its environment and vice-versa, and the impact of the environment on those who live and work in it and give it its shape. To this relationship, I want to add two closely related elements: time and the impact of the environment on the viability of its inhabitants or "components." As a geologist, I was trained to study, for example, the evolution of a fossil species through time, and how to interpret changes of specific parts of such fossils as the functional adaptation of that organism to alterations in its environment. Darwin taught us that those organisms that are best adapted to their new environment have the best chance to survive. In other words, studying these functional adaptations helps us understand the impact of the environment. My assumption is that the Darwinist principle is also applicable to the evolution of museums. The role and shape of these museums have changed dramatically over the centuries: what started as a Cabinet of Curiosities for the elite has become a theme park for the millions. Subsequent appearances thus can be interpreted as responses to a specific combination of requirements and conditions which change through time and differ from place to place, according to the social, cultural and intellectual environments.

I do not have the intention to rewrite the history of museums and collections of science. This has been dealt with extensively by a great number of authors.[1] Neither is it "new" to claim that museums have gone through "generations" or "phases." The aim of this paper is to present a way of looking at museums as products of their time and environment. My purpose is not only to understand the development of museums and collections, but also to look at their evolution as a tool to plan a viable future for the institutions for which we are responsible.

When we look at the characteristics of early museums of science, we must realize that we cannot apply the criteria and definitions of today, but that we must look at them as products of their time. They functioned in the scholarly environment of their age and played a specific role in context, as do current museums of science. For terminological clarification, "science" is used throughout this paper in the broad, continental definition of *wetenschap*, covering the full spectrum of human knowledge from mathematics to humanities. Museums of science, therefore, are being considered here as those which deal with the broad spectrum of human knowledge and its related artifacts. Thus, a "museum" is any institution, building or room which holds artistic, historical or scientific objects for reasons of preservation, study, contemplation and exhibition. Assembling objects, studying them and maintaining them within a specific intellectual environment is an essential role of such museums. In short, museums are institutions that keep collections for research and presentation. It is the latter aspect of museums that I concentrate upon in the context of this paper.

A New Classification

Already before 1996, when the Utrecht University Museum moved to its new premises, I felt the need for an instrument that could help in the design of the new museum for which I was then responsible. As I saw it, this museum had a dual task: the care of the historic scientific heritage of our university (and related collections) and the promotion of public understanding of science, illustrated by the achievements of our scholars. To begin with, I wanted to understand better our position in relation to other museums of science, and particularly, how a university museum with a rich historical collection should respond to the boom in science centers (de Clercq 1989).

In literature, we can find several different classifications.[2] Typically, these classifications lack clear and objective discriminating criteria and frequently are based on biased assumptions, leading to contradictions and confusion. More particularly, these descriptions usually start with the *Conservatoire*

National des Arts et Métiers (CNAM) in Paris (1794) and the Science Museum in London (1857), ignoring the Cabinets of Curiosities from the Renaissance and the Learned Cabinets from the Enlightenment. The fact that most university museums and collections have their roots precisely in these early museums of science was my main motivation to develop a new classification. Furthermore, while designing the museum of science of the future, it is essential to use well-defined terminology to avoid confusion and getting stuck in semantics.

Looking at developments of museums of science in the western world over the last four or five centuries, we can distinguish five major typologies: Cabinets of Curiosities, Learned Cabinets, Museums of Science and Industry, Museums of the History of Science and Science Centers, which can be regarded to constitute subsequent phases in the development of scientific museums and collections. These "generations" should be seen here as "archetypes," as the way such museums were conceived in their early mature phase. Their appearance mirrors the intellectual, social and cultural setting of the time. Only a few of these museums still show their original conceptual organization, layout and architecture. Most have changed through time; they have gone through the natural developments of all museums of science, reflecting the developments in the scientific world and the changing requirements of the environment, contemporary fashion and local desires. As a result of the need to "keep up-to-date," today most museums of science show a mixture of characteristics and functions.

Looking at the way museums of science have evolved, we can see, for example, how the role and status of the object has changed from an almost sacred relic to a disposable interactive prop. The same is true of the user: in the beginning we see a noble gentleman, then an inquisitive scholar and today the public at large. Whereas in the early days, user and owner were one and the same, today the owner may be a public-private combination, with the primary aim to boost the economy of the area. The classification I present here takes such factors and parameters as discriminating criteria, and sets them against the background of the social, cultural and intellectual context (Fig. 1).

Earliest Museums of Science

Eve's act of picking an apple from the Tree of Knowledge in the Garden of Eden for Adam to taste heralds the crucial role objects have played in the gathering and dissemination of information. However, the development of an elite class of rulers and bureaucrats was necessary before any formal education was possible. In all great cultures of the world, the education of the elite was in the hands of spiritual leaders. The earliest proof of an institutionalized form of education using objects resulted from excavations done by Leonard Woolley and P.R.S. Moorey at the beginning of the twentieth century. Woolley and Moorey excavated a temple complex in the ancient city of Ur (Mesopotamia), where the E-Dublal-Mah temple contained a school (dated ca. 580 BCE) with "antiquities" of the 3rd millennium (2900 – 2000 BCE) of Sumerian origin (Geerts 2003, L. Geerts *in litt.* 03.31.2003). Collecting objects for curiosity or the enhancement of knowledge eventually led to what we today call "museums," a word derived from Ptolomy's *Museion* in Alexandria. The *Museion* was a state-run institution dedicated to the muses (including history, music and astronomy), with research and teaching as primary goals. Since the *Museion* did include collections, which were used in a scholarly context, we can point to it as one of the roots of early museums of science.

Little is known about the history of collections in the western world between the *Museion* and the Renaissance. Of course, precious objects and relics were kept at the courts and by churches and cloisters. For centuries, churches were the only places where the public at large was confronted with works of art; apart from the aesthetic experience, these works of art had the didactic function of illustrating Biblical scenes. In this respect, churches performed the role of museums (Shelton 1994; J. Gorman *in litt.* 20.10.2003). Probably most cloisters had gardens with vegetables and fruits, flowers for the altar and medicinal herbs. These gardens can be regarded as the ancestors of the academic medicinal or botanical gardens, the first of which were founded in 1540 at the universities of Padua and Pisa.

Noble Cabinets of Curiosities

From the early Renaissance onward, we find collections of precious artifacts at the courts of the aristocracy. These *Kunst-* or *Wunderkammer* contained portraits of ancestors and celebrities, paintings, prints, classical artifacts like sculpture, vases and coins, porcelain and elaborately worked suits of armor, but also sundials and other scientific instruments, precious stones and curious objects from distant lands, like a splinter of the Holy Cross brought back from the Crusades. Other "rarities" would come from distant parts of the world, including silk from India, spices from the Moluccas, porcelain from China, ivory from Africa or gold from Mexico. These cabinets often contained a library and occasionally had a laboratory for alchemical experiments. Surviving inventories give a good idea of the design and organization of these cabinets. They displayed an almost encyclopedic representation of the known world, encompassing mankind and the rest of the living as well as mineral world. Objects, deliberately chosen for their intrinsic beauty, meaning or value, were often expensive masterpieces, as is illustrated by the magnificent scientific and mathematical instruments from the Medici collection, now in the *Istituto e Museo di Storia della Scienza* in Florence, often bearing the Medici coat of arms. The splendor, rarity and value of

Typology, Generation	Cabinet of Curiosities	Learned Cabinet	Science Museum	Museum of History of Science	Science Center	Museum of Science of the Future
Archetypes, Examples	Francesco I de' Medici, Rudolph II of Habsburg, August I & Christian I of Saxony, Hessian Landgraves	Ulisse Aldrovandi, Frederick Ruysch, Ashmolean Museum, Teylers Museum	Conservatoire Nationale des Arts et Métiers, Science Museum, Deutsches Museum	Istituto e Museo di Storia delle Scienza, Museum of the History of Science (Oxford)	Urania, Palais de la Découverte, Evoluon, Exploratorium	
Role of Object	Precious, icon, relic, Represents the world, Reflects status owner	Primary source of information, Catalogues the world	Demonstrates skills & progress of industrialized world	Testimony, Material evidence	Demonstration of phenomenon, scientific principle or concept	Source of information, Authenticity, Adds time dimension
Type of object	Authentic	Authentic	Authentic, Instruction model	Authentic	Interactive props, disposable	Authentic, 'Intangible' *Documents humaines*, Interactive props
Use of Object	Admiration, Demonstration, Hands-off	Examination & classification of the world, Hands-on	Admiration, Demonstration, Hands-off	Reference, Instruction Interpretation, Hands-off	Interactive experiment, Experience, Hands-on	Experience, Interpretation, Hands-on & -off
Arrangement & ordering of Objects	Importance, value, meaning, allegoric, Aesthetic	Systematic, Specialization, Functional	Thematic, Instructive	Thematic, Historic setting	Disciplinary, Didactic, Entertaining	Interdisciplinary, In context, Stimulate debate
Purpose & function Institution	Contemplation, Reflection on temporal power & intellectual status	Investigate, catalogue, classify & collect the world, Encyclopedic	Demonstrate skills & progress of industrialized world	Archive & repository Document & illustrate the history of science	Promote public understanding of science	Science education, Science participation, Science is part of culture & society
Owner	Aristocracy, Intellectual & social elite	Elite, University, Learned Society	Government	University	Public-Private	Public-Private partnerships
User/Public	Aristocracy, Intellectual & social elite	Scholars & students, Elite & Upper-middle classes	Lower-middle & working classes, Schools	Scholars & students, General public, Schools	General public, Schools, Tourist Industry	Public at large, Specified target groups
Location	Schatzkammer, Court, Studio	Private cabinet, Academic laboratory (= museum)	'Museum castle'	University Museum	'Theme Park'	Museum without walls, Virtual museum
Legal status	Private	Private, University	Government	University	Private sector	Public-private
World view	Renaissance, Humanism	Enlightenment, Encyclopedism	Positivism	Modernism	Democratization, Progress	Emancipation, Heritage awareness
Social, cultural & intellectual setting & context	Knowledge from early writings, Veneration of rare & miraculous, Early universities	Scientific Revolution, Voyages of discovery, Learned societies, Proliferation of science	Industrial Revolution, Great Exhibitions, Science goes public, Education reform	Awareness to heritage, Teaching & research in the History of Science	Information Revolution, WW-II & Sputnik-effect, Limits of Growth	Urbanization, Globalization, Science illiteracy, Long-life expectancy

Fig. 1. This table shows the classification of museums of science presented in the article, based on their form as an expression of functional adaptation to their environment: a schematized representation.

the objects reflected the status and worldly power of the owner. One of the objectives of the *Schatzkammer* of Emperor Rudolph II was to demonstrate the absolute power of the Habsburg house over its subjects. On the other hand, quite a few of these collections—like those of the Hessian Landgraves in Kassel and the Medici dynasty—were meant to be an illustration of patronage and encouragement of scientific research, as well as a demonstration of the learned inclination of the court.

"Cabinets of the World"

Gradually, from the sixteenth century onwards, other members of society started to assemble collections. Among these citizens we find merchants, doctors, apothecaries, clergymen and artisans, like silversmiths and painters (Rubens, Rembrandt). The possession of a collection contributed to the social status of the owner, and this fact certainly explains why wealthy gentlemen became collectors. These collections, however, also reflect the curiosity triggered by the stories and objects that came home from the voyages of discovery, which in turn contributed to the Scientific Revolution. Although such cabinets still held both *artificialia* and *naturalia*, we do see a clear tendency towards specialization. The well-known image of the cabinet of the Neapolitan pharmacist Ferrante Imperato illustrates the close relationship between his profession (apothecary), the composition of his collection and the way in which the cabinet was used for the education of apprentices. These "cabinets of the world," brought together by inquisitive professionals, preceded the establishment of the Learned Cabinets.

One of the characteristics of these early collections is that founder, owner and user of the cabinets are usually one and the same person. This, as we will see, is in contrast to the Learned Cabinets, which gradually became "institutionalized" as the property of universities or learned societies to be used by scholars and students.

Learned Cabinets

Probably the most important aspect of the Learned Cabinets was the new and innovative role of the object. The outward appearance of the object no longer mattered; the objective information intrinsic to the object became of prime importance. The story the object can tell to the inquisitive mind obtained central stage. Objects became a primary source of information, which could be unraveled and studied through dissection, the use of the microscope, analysis and comparison. This novel information added to a better understanding of the living and mineral world and contributed to the admiration of the marvels of God's Creation.[3] Although many early Learned Cabinets, like those of Ole Worm nd the Jesuit Athanasius Kircher at the *Collegio Romano* in Rome, still contained both *naturalia* and *artificialia*, specialization gradually emerged. Ulisse Aldrovand, for example, amassed an important natural history collection, the remains of which are now magnificently displayed at the *Museo Palazzo Poggi* of the University of Bologna. Other examples of specialized collections are the anatomical preparations of Frederik Ruysch, parts of which were bought by Tsar Peter the Great and shipped to St. Petersburg. Most Learned Cabinets probably were set up by private collectors. Some, like Albertus Seba, would gain great fame with their collections of natural specimens. The renown of the collections and the willingness to allow students and scholars to study them was often a decisive factor in the appointment of a chair at a university. Sometimes, the university would buy these collections, but it was not uncommon that collections remained private property and became dispersed after the death of the owner. In some cases, however, they would be donated to a university. In this way, the collections of John Tradescant, father and son, were donated to the University of Oxford to become the Ashmolean Museum (1683), the mother of all—university—museums. The museum assembled objects of study, and it also included a library, a study room and often a laboratory for closer examination of the objects, and a cabinet where the collections were kept in a specific functional order reflecting the institution's intellectual environment.

About one century later, the merchant Pieter Teyler van der Hulst donated his collections and fortune to establish the Teylers Museum in Haarlem (1784). The foundation of Teylers museum occurred at a time when Learned Societies flourished during the second half of the eighteenth century. Many were founded and functioned in close collaboration with the local university and could be specialized in, for example, natural history or physics. In Utrecht, the university physics cabinets and the cabinets of the *Natuurkundig Gezelschap* (1777) were kept together and finally became the core of the Utrecht University Museum (1928).

As illustrated above, these collections gradually moved from the private into the public realm. They became increasingly specialized and formed the core of collections for research and teaching at our institutions of higher education. By being studied, and having the results of these studies published, collections became reference collections, and thereby "institutionalized." I see the Learned Cabinets as the forerunners of today's university museums and collections. This is especially true for natural history collections, because it generally is unimportant if the object were collected centuries ago, as long as it is well-preserved and has sufficient documentation—and in some exceptional cases even that is not required.[4] Science progressed over the years, new techniques and new insights arose, permitting new and hitherto unthought-of questions to be asked, but the function and role of the object and collection, as well as its users, remained basically the same.

Science Museum

The original purpose of museums of science and industry is different from that of their predecessors. They are a typical product of the Industrial Revolution and often the offspring of one of the great World Exhibitions, like the Great Exhibition in the Crystal Palace (1851), which gave rise to the South Kensington Science Museum. For the first time, large parts of the public, including the lower-middle and even working classes, were given the opportunity to get in touch with the achievements of modern science and technology. Both the exhibitions and the museums were initiated, founded and run by national governments; influential scientists and/or captains of industry often played an important role as initiators. Apart from the promotion of trade and tourism, education of the public and the need to train and attract skilled labor were among the driving forces.

Contrary to Learned Cabinets, the role of the object and the purpose of the institution was to demonstrate the progress of the industrialized world and to stimulate trade, competition and craftsmanship. The objects were displayed with great care in beautiful and specially-built showcases, and sometimes working models were presented to demonstrate functional aspects.

As time passes, and the museum continues to accumulate instruments and machines that show innovations, the museum gradually becomes a repository. The responsibility for the maintenance of the scientific and technological heritage may easily become a cuckoo in the nest. Furthermore, the rate at which the objects become outdated is progressively in conflict with the primary purpose of the institution—the education of the public with state-of-the-art developments in science and technology. Against this background, we must understand the development of two new types of museums of science: the Museum of the History of Science and the Science Center.

Some of the larger science museums continue to combine these categories, like the South Kensington Science Museum and the Smithsonian Institution's National Museum of American History in Washington DC.

Museum of the History of Science

Traditionally, the instruments, telescopes and lenses kept in academic cabinets of physics and astronomical observatories were treated with great care and kept in special cabinets, usually in laboratories. These objects would be used repeatedly for many years, particularly in the education of students. During the latter part of the nineteenth century, research became the second primary task of universities, and the use of these objects changed quite dramatically, as a range of new instruments was introduced and existing ones turned obsolete. After World War I, various initiatives in a number of European countries led to the establishment of Museums of the History of Science:

- Museum of the History of Science, Oxford, 1925
- *Istituto e Museo di Storia della Scienza*, Florence, 1927
- Museum Boerhaave, Leiden, 1928
- Utrecht University Museum, 1928
- Whipple Museum, Cambridge, 1944

Most of these museums are found in academic environments. Their goal is to assemble, study and display the valuable historic scientific instruments scattered in their institutions, and to preserve them as evidence of the history of the institution and its famous scholars and alumni. Many of these museums, in one way or another, are related to research and education in the history of science and aim primarily at scholars and students in that field.

Science Center

Science centers differ fundamentally from museums of science, as they primarily are devoted to science education instead of the care of objects. Science centers use purposely built (and disposable) hands-on or interactive devices, so-called "props," instead of real objects. These props are developed to demonstrate a particular physics experiment, scientific principle or natural phenomenon; they are models instead of authentic objects from the real world and are arranged in a didactic and entertaining way, transmitting the message that "science is fun." In this way, science is presented as a one-way success story, usually with little attention to the interdisciplinary and open-ended scientific process of trial and error, for the human and social context or for science as an ever-present and indispensable component of our daily world. Science centers cater to school-groups and the general public, including tourists.

Urania (Berlin, 1889-1928) is called by some authors the prototypical science center. Devoted to "the pleasure of scientific discovery" (Lührs 1992), it exhibited no less than 88 physics experiments that could be controlled via simple electrical devices. *Urania* closed in 1928 due to the post-war economic crisis, leaving no recognizable trace except one photograph. Consequently, most historians refer to the *Palais de la Découverte*, created in 1937 after the 1936 Paris World Exhibition, as the first science center devoted to science education of both young and old with the use of interactive devices. Other classical examples include the *Evoluon* (Eindhoven, 1964-1989), which was founded by Philips and closed after 25 years, the Exploratorium in San Francisco (1969) and the Ontario Science Center in Toronto (1969).

The birth and success of science centers can be interpreted as a response to a widespread need for reform

in science education prompted by, among other factors, the impact of World War II, the so-called Sputnik-effect, the "belief" in progress due to "value-free" (i.e. "clean") science, the democratization of knowledge and education, the study *The Limits of Growth* by the Club of Rome (1972) and the pressure from industry to recruit young scientists. Traditional science museums had become inflexible dinosaurs, repositories for objects from the past, unable to satisfy these new social demands. Notwithstanding efforts to develop special galleries like the Launch Pad at South Kensington's Science Museum, museums of science and technology increasingly triggered nostalgia instead of excitement about new discoveries.

The explosive growth of the population in areas without traditional collection-based museums also created opportunities for innovative hands-on science education initiatives. Frank Oppenheimer's Exploratorium in San Francisco is a world-famous example. Since its beginning, the Exploratorium served as a model for hundreds of science centers all over the world. The publication of the Exploratorium's *Cookbooks*, offering a detailed description of its exhibits, invited imitation and proved a decisive factor behind the boom in science centers. In the seventeenth and eighteenth centuries, a clearly visible tower for astronomical observations contributed to the status of a town and its academy, and it became fashionable to have one. In a similar way, the success of science centers and their ability to attract large numbers of visitors was such that city councils and local governments all over the world started competing in setting up science centers. Architects were hired to build spectacular and glamorous high-tech buildings that would act as landmark and attraction. Although form should follow function, ambitions to create an architectural landmark lead to perhaps beautiful but inefficient buildings, excessive operating costs and the subsequent shift of the primary goal from science education to the attraction of large numbers of the public. As a result of the need to concentrate on visitor numbers instead of content, many such initiatives led to both conceptual and financial disappointment, which in turn triggered an unfortunate climate of reluctance among universities, politicians and industries to invest in museum-based science education. The effect of the availability of ready-made interactive devices (or even complete exhibitions with a minimum floor space of 700 m^2) was that many science centers gradually became institutionalized hands-on exhibition centers, with the use of interactive devices as a goal in itself, whereas the science center movement as such has lost its direct link to the scientific world.

Furthermore, the ill-defined use of the word "science center" is not helpful in the discussion of how best to tackle museum-based science learning or how to develop a new museum of science. A recent study informs us that there may be about 1500 science centers or science-center-like institutions in the world today, with an attendance exceeding 275 million visitors a year (Persson 2002). Science centers would be extremely successful if they could indeed boast such figures. However, in his study, Persson defined a science center as:

> A physical venue using interactive exhibits to popularize science or technology for a general audience. It may use other methods, as well. In this broad definition, some institutions that primarily classify themselves as e.g. natural history museums or aquaria may be included. (qtd. in M. Quin *in litt.* 06.11.2002)

In other words, although Persson's study illustrates the success of contemporary science museums and science centers,[5] it remains unclear which part of this success can be attributed to "real" science centers[6]—as an "institution"—and which part to science museums that make use of interactive exhibits as a technique. Clearly, a substantial part of these figures come from the wide range of traditional science and natural history museums, zoos etc. that have introduced interactive exhibits in their displays. It is by consequence unclear, unfortunately, which part of the success can be attributed to hands-on techniques and which part to the authentic object; neither do we know whether it is the intrinsic beauty of the object that triggers the imagination, or the story it can tell.

Museum of Science of the Future

As we have seen, over the years museums have played a considerable role in science education and certainly will continue to do so. The growing demand for young people pursuing scientific careers opens new perspectives and opportunities for museums of science. For those considering how to "modernize" their existing museum or to start a new one, it may be tempting to look only at successful initiatives around the world or even merely to copy one of these. However, it is quite possible that circumstances in the local environment are fundamentally different and chances are high that doing so will lead to failure (as illustrated by the Amsterdam Science Center *New Metropolis*, today *Nemo*). Therefore, before embarking on the design of a new or renewed museum of science, one has to consider carefully one's position and environment, including the demands of stakeholders, the expectations of visitors, the cultural and intellectual setting, the educational system and the quality of the collections.

Obviously, it is impossible to provide the all-conclusive recipe for the successful museum of science of the future. First of all, its characteristics clearly will be determined largely by the situation of departure, including the presence of an already-existing museum, its collections, the ambition and the scope of the mission, the expected number of visitors, the architecture, other

attractions in the area, etc. Then, of course, to have a fair chance to survive and even become successful, the initiative must be attuned to the local environment and conditions. The sad experience is that all too frequently, the ambition of the founder proves unrealistic and does not take the local characteristics into account.

For larger, already-existing museums, the mere size of their collections compels them to adopt a large setup, requiring considerable investments causing maintenance and operation to be costly. Those that start from scratch, however, are free to conceive their own model. In this respect, universities (or university museums) are, to a certain extent, in a privileged position: their collections are usually of high quality and cover a wide range of disciplines, enabling an interdisciplinary approach. Furthermore, they have easy access to the wide range of resources in academia. On the other hand, most university museums are forced to work on a modest scale, because universities generally work under financial constraints, and do not regard keeping museums as a priority. The challenge, of course, is to turn this apparent incongruity and disadvantage into a strong point, to take advantage of the fact that the museum belongs to the university and is obliged to work on the human scale, to do interdisciplinary work, to reach out into the public domain and thus show science to be an integral part of our society. At this point, I wish to stress again the need for science to be presented in the broadest possible way, encompassing all fields of human interest and scholarly research.

The challenge for the future is to find a contemporary and fresh formulation of the science center, which most likely will seek to integrate science education techniques developed by these centers and the use of the authentic object. Although it is impossible to predict the definitive design of the successful museum of science of the future, it is possible to draw some conclusions from the way current prevailing worldviews and global trends will probably affect discriminating factors and shape future museums.

a) The Purpose & Function of the Museum

Collections will no doubt continue to be the core business, in fact, the *raison d'être*, of museums. After all, urbanization and the increased use of IT (Information Technology) have rapidly transformed the museum into one of the rare places where the public can get in touch with the real object, the story it can tell and the culture it represents; this is particularly true of objects from nature. The possession of collections of high quality and the way they are used by the museum and made available to the public will become one of the discriminating factors and a key to success. Here lies a unique chance for university museums.

Science education always has been part of the mission of the museum of science. This will increase, partly due to the decline in the use of objects for research, but also due to the need to attract students for a scientific career. Since this is a point of serious concern all over the world, it is likely that the public sector will take its responsibility and create openings for innovative initiatives. Museums can seize the opportunity and play an active role in science education, making it one of their main tasks.

Science participation follows naturally from science education. A growing number of well-educated, active elderly people (due to demographic developments and increased health and life expectancies) are eager to participate in intellectually challenging and relevant activities. Moreover, citizens increasingly are asked to have their say in political matters that involve sometimes-difficult scientific issues. Museums can offer such facilities and thus strengthen their position in society and demonstrate that science is indeed part of our culture and society.

b) The Object

Objects remain the **primary source of information**. Models, and later interactive devices, have been developed in addition to real objects mainly for educational reasons. This trend reached its climax in the science center movement. The reappraisal of the authentic object and the opportunity for museums to profile themselves guarantee a continued central role for the object in the museum. Traditionally, museums of science displayed objects because they had played an important role in research or were just beautifully made. The challenge for the future will be to display the object for the reason it has been collected: to be a source of information. Museums will continue to use interactive devices, as well as science education techniques and methodologies developed by science centers. The demands of a well-educated and emancipated public and the need to compete with readily available IT-science programs will stimulate museums to display their objects in a wider context, integrating artifacts and knowledge from various disciplines.

Future museums of science will also—to quote Kenneth Hudson: "Place science and technology firmly in their social context" (Hudson 1987).

Museums must be without walls. There is no good reason to restrict science education and/or science participation to within the walls and traditional hours of museums. IT will allow much wider access to the collections and the development of virtual museums. Also, museums will be active in all kinds of outreach activities, including field excursions. The opportunity to study the traces of the impact of science and technology, which we can find everywhere around us in their actual context, will contribute considerably to their understanding, as well as their impact on society and natures, and the worldview from which they originate.

c) Public, The User

The ability to adjust to changes in the environment is a decisive factor for survival, particularly in this field. Museums of the future will continue to cater to their traditional public; they will welcome students and historians of science to work on their collections, as well as the well-educated public at large. Traditional clientele will remain one of the pillars of their existence and there will be programs to support the continuing need to recruit science students.

However, this will not be enough. It will be necessary to consolidate the museum as an integral part of society and respond to demands and opportunities. I have already pointed to the growing group of the elderly and mentioned "science participation" as an instrument to integrate the museum in society. Looking back at the history of museums, only those that were able to respond to the demands of their environment have proven to be viable. For the future of museums, this implies that we must learn to resist the temptation of setting up a museum (or exhibition) from the "supply approach" only, based on the enthusiasm of the curator. Instead, museums must learn to listen to the demands and questions raised by the public. The future public will be well-educated, emancipated and demanding and will expect authenticity, scientific integrity and social relevance. University museums, operating in an academic environment, are particularly well-equipped to respond properly to this demand.

In conclusion, my aim was to develop an instrument to help me design a museum that had a fair chance to fit in its environment and respond to the demands of its public—in other words, a successful museum. We have seen the influence of prevailing worldviews and intellectual setting on parameters like the role of the object, the way it is used and the kind of user (i.e. the public), and we have seen that it is vital for the survival of any museum to engage its community. It follows from our observations that copying a success has a fair chance to lead to disappointment, unless the institution is attuned to its new environment. Planning a viable museum therefore requires an understanding of the past, as well as an analysis of the environment in which it is supposed to operate, including its public and its stakeholders.

The ambition and goodwill of the founder are essential factors for a successful museum. However, it is my conviction that the interaction with the environment eventually will determine whether the museum will be successful. From this, it follows that a museum in Oklahoma will be different from one in Tartu. Similarly, a museum conceived by a city council to boast the tourism industry will differ from another established by a university that cherishes its historical collections and desires to raise its profile through the display of its collections and the scholars that brought them together.

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Notes

[1] See Lewis, Boylan and Lourenço.

[2] Most authors refer to Danilov's classical paper, written in 1976 while he was director of the Museum of Science and Industry in Chicago.

[3] Which, according to James Ussher, took place on the 26th of October 4004 BCE at 9:00 am.

[4] The bone fragments from the Oxford Dodo were saved from a fire and poorly documented. Nevertheless, these fragments enabled the phylogenetic classification of the Dodo as an oversized, flightless pigeon.

[5] Miller's report includes a section on the impact of science museums and science centers on the promotion of the public understanding of science, based on the ECSITE report by Persson. Persson's report does not include those science museums, zoos, botanical gardens, aquaria, etc. that do not make use of interactive exhibits. The total number of visitors to science museums at large will therefore be considerably higher.

[6] In my perception, "real" science centers are institutions whose mission focuses on informal science learning through the use of interactive exhibits.

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